CHAPTER 6

PIER AND WHARF LAYOUT

6-1. Introduction.

a. Definition.

(1) *Pier.* A pier is a structure extending outward at an angle from the shore into navigable waters and normally permitting the berthing of vessels on both sides along its entire length.

(2) *Wharf.* A wharf is a structure extending parallel with the shoreline, connecting to the shore at more than one point (usually with a continuous connection), and providing, in most cases, berthing at the outshore face of the structure only.

b. Functional requirements. Piers and wharves provide a transfer point for cargoes and passengers between land and water transportation carriers. The pier/wharf complex may provide the following facilities:

(1) Berth capacities of sufficient depths and widths to allow safe vessel approach and departure.

(2) Sufficient mooring devices to safely secure vessel.

(3) Access for railroad and highway facilities.

(4) Storage space for open or covered cargoes.

(5) Cargo handling equipment.

(6) Fender system.

(7) Administrative and maintenance facilities.

(8) Fire protection and fire fighting equipment.

6-2. Deck structures.

a. Pier or wharf arrangement. The arrangement of berths should fit the proposed site without encroaching on pierhead or bulkhead lines, with consideration given to the depth contour below which the driving of piles is impractical. The types of pier and wharf layouts are shown in figure 6-1.

b. Pier and wharf length. Pier and wharf lengths should be as follows:

(1) *Single-length berth*. Dock length should equal the overall length of the largest vessel to be accommodated, plus an allowance of 75 feet at each end of the vessel. For preliminary design, the following approximate pier lengths may be used:

Vessel type	Pier length, ft
Lighters	150
Submarines and destroyers	450
General cargo ships	600
Cruisers	750
Container ships	1,000

(2) *Multiple-length berths*. Dock length should equal the total overall length of the largest vessels simultaneously accommodated, plus allowances of 75 feet between the inshore end of inboard vessels and the bulkhead and 75 feet between the outboard end of outboard vessels and the end of the pier. Allow about 50 feet between vessels. For preliminary design, pier lengths should be approximately (n) times the berth length given in paragraph 6-2b (1) (where n = number of vessels of a given type berthed end to end at a single pier face).

c. Pier width.

(1) *Berth in outboard face*. Outboard face berth widths should be adequate for vessel accommodation. The width requirements may be obtained from the pier lengths given in paragraph 6-2b.

(2) *Berths only alongside pier*. The total width should be the sum of the width requirements for the pier shed, aprons, and lanes for railroad, trucks, and crane service. In no case should the width be less than that required for lateral stability. The minimum pier width should be 25 feet clear between curbs. Where railroad tracks, truck lanes, or craneways are to be installed, the following width requirements should be followed:

(a) Railroad tracks. Except where local conditions require otherwise, standard gage should be used for trackage.

(b) Truck lanes. A minimum of 15 feet should be provided.

(c) Craneways. Width requirements depend on equipment selected for pier service.

d. Wharf width. There are no definite width requirements, but sufficient area should be provided for storage and for truck and rail access. An apron should be provided along the outboard face. For general cargo wharves, the required width for aprons, shed, and upland facilities should be about 300 feet. The width may be increased for container wharves.

e. Slip width. Clear distances between piers will be adequate for the safe berthing of the required maximum size vessels, plus clearances for the safe working of tugs and barges, lighters, and cranes operating between vessels. Where multiple berthing is provided, clearances shall be sufficient for dispatching the vessel at the inboard berth without moving the vessel at the outboard berth. The width should not be less than 3 to

4 times the largest accommodated vessel beam for single berthing, or 5 to 6 times the beam of the largest accommodated vessel for berthing two abreast. These requirements apply where vessels are berthed on both sides of the slip. Where vessels are berthed on one side only, the slip width may be reduced.

f. Aprons. The width of an apron will depend upon the use of portal or semiportal cranes and the number of railroad tracks and truck lanes, if any. The minimum width should be 20 feet. Where railroad tracks are carried on aprons, the apron width should allow for passing of train and trucks (or other material handling devices on the piers), plus allowances for the piled cargo on the aprons. Railroad tracks should be located along the outboard face of marginal wharves. Various apron widths for different operating conditions are shown in figure 6-2.

g. Deck elevation. Deck elevations for various types of construction and for particular situations are listed below. Except for the minimum elevations specified, pier deck levels should conform to the generally established levels of adjacent station property.

(1) *Flood protection*. To avoid flooding, provide deck elevations at or above maximum high water plus the half-height of an incident wave.

(2) *Two-deck piers*. Where a tidal range is large, deck height may interfere with cargo handling at low tide. In this case, the pier may be constructed with two levels, one for use at high tide and the other at low tide.

(3) *Concrete deck.* Where economically feasible, pile cap soffits should be 3 to 4 feet above mean high water.

(4) *Timber construction*. Where timber construction is used, the lowest tier of braces should be at or above the mean tide level, with the deck level adjusted for the required bracing depth.

(5) *Steel construction*. Except for piling, steel framing should be kept above mean high water. Adjust the deck level for the required construction depth.

(6) *Loading platforms*. Loading platforms are desirable on piers where materials are transferred by trucks or freight cars. The loading platform height should be 3 feet 9 inches, and the width should be 16 feet. On straight railroad tracks, a clearance of 6 feet should be provided between the edge of a loading platform and the center line of the adjacent railroad track. On curved tracks, this clearance should be increased by the amount of the center or end excess and provide access to platform ends by ramps.

(7) *Crane and railroad tracks*. These tracks should be flush with the pier decks or pavements.

h. Water depths in slips. Except where heavy silting conditions require greater depth, at individual berths at low tide, the depth should equal the maximum loaded draft of the largest vessel to be accommodated, plus 4 feet. On a mud or silt bottom, consider increasing the water depth requirements if an investigation indicates probable fouling of condensers on the vessel due to proximity of the mudline to the bottom of the vessel. Where the vessels to be accommodated are specifically known, the following values may be used:

Vessels	Depth, ft[1]
Small boats and seaplanes	6 to 12
Submarines and destroyers	30 to 35
Cruisers and general cargo ships	35
Container ships	40

[1]These depths are based on mean low water (MLW) or mean lower low water (MLLW) statistics for the area under study.

6-3. Transit shed.

a. Introduction. A transit shed is required for handling goods that must be protected from the weather. Where nonperishable goods (not subject to weather damage) are handled, open storage areas may be used in lieu of sheds. Covered sheds are not required for container slip wharves.

b. Storage area requirements. The total storage area in pier sheds should conform to project requirements. An area of 90,000 square feet has been found to be about the minimum space needed for one berth. For general cargo, allow 40 cubic feet of volume per ton and 50 percent of shed area for aisles. Upland storage for each berth can be provided equal to 2.5 to 5 percent of the annual general cargo volume handled.

c. Shed Width. Shed width shall conform to the following criteria:

(1) *Single-story sheds*. Transit sheds should be one story high. The width of a single-story shed (less width of the outboard apron) is obtained by dividing the pier storage area requirement (including allowances for office, toilet, passenger, and miscellaneous areas) by the length of the pier.

(2) *Multi-story sheds*. These sheds are not normally economical because of heavy line load requirements and operational difficulties. Where pier widths are limited because of adjacent piers, high costs, or limited availability of waterfront property, multi-story sheds may be required. The width of a multi-story shed equals the width required for a single-story shed divided by the number of floors (plus allowances for ramps and elevators between floors).

d. Vertical clearance. Provide 20-foot height or more to the undersides of beams or trusses. Clearances of 22 feet are required where railroad tracks are run into a shed and 24 feet where cargo is to be handled in the shed by mobile cranes. Clearances should comply with the loading capacities of forklift trucks or other cargo handling devices used on the piers.

e. Column spacing. Longitudinal and transverse spacing along and across the piers is specified as follows:

(1) *Longitudinal*. Column spacing along the length of the piers is generally determined by the sizes and spacing of the cargo doors with a column supporting a door buck. The shed columns should be located over the substructure pile caps. Column spacings of 15 and 25 feet are considered normal.

(2) *Transverse.* Spacing of columns across pier widths should allow for aisles between the stacked cargo to permit movement of forklift trucks and other cargo handling devices. A minimum aisle spacing of 40 feet should be provided. For single-story sheds, consider eliminating all interior columns where the roof live load does not exceed 30 to 40 pounds per square foot, and where the shed width does not exceed 100 to 130 feet.

f. Door size and spacing.

(1) *Cargo doors.* The cargo doors should be sized to accommodate any special packages handled at the building. The minimum size for cargo doors should be a 16by 18-foot clear opening. Spacing between cargo doors should be 36 to 38 feet with alternate dead panels, or 30 feet without alternate spacing. For narrow aprons, provide doors in every bay. Where apron widths are narrow, cargo door heights should be increased to permit sling loads to swing through the door. The rolling shutter or sectional, vertical lift type is preferable. Provide bolts and locks that are operated inside the shed and also wheel guards for the door frames.

(2) *Access doors*. Where trucks are permitted to enter a shed, access doors of the inboard face should be a minimum of 14 feet high by 12 feet wide.

(3) *Shed doors.* Along railroad tracks, space doors at 42or 44-foot intervals for the best corresponding spacing of railroad car doors. These shed doors should have minimum openings 14 feet wide by 12 feet high.

(4) *Truck loading.* At shipside and in truck loading areas, doors should be continuous with shed columns supporting the door bucks.

(5) *Railroad doors*. Doors through which railroad cars pass shall be 22 feet high. Widths shall conform to either single or double-trackage clearances, (figure 6-2).

g. Fire protection. Fire protection should be in accordance with AR-420-90.

h. Miscellaneous. Installation of lighting and ventilation should conform to those contained in appropriate Army manuals. Partitioned offices shall be provided for supervisory personnel. Rooms should also be provided for stevedore's gear, lockers, washroom, toilets, and guard rooms.

6-4. Approaches.

a. Introduction. Approaches are required where piers are located offshore. Approaches should be in the form of trestles or a causeway. Trestles should be used where tidal flow obstruction must be minimi7ed.

b. Dimensions and clearances. Two truck lanes, plus necessary railroad or crane trackage, should be provided. The minimum width should be 24 feet clear between curbs. The 60-foot wide causeways are recommended for modern container wharves. For offshore wharves, where approaches are short and cargo handling requirements are heavy, provide double approaches for single berths and two-lane approaches at 500-foot intervals for multiple-length berths. This arrangement will provide continuous one-way traffic past each berth. A triangular deck area should be provided at the intersection of the approach with the wharf to permit 90-degree turns on and off the wharf. These triangular areas should be made at 45 degrees and are generally about 35 feet on a side. For marginal wharves, provide continuous access.

6-5. Roll-on/roll-off ramps.

No general solution was found to the problem of providing facilities for discharging commercial roll-on/ roll-off ships. There appears to be no standard height above water level of either side doors or stern ramps. The difference between loaded and light draft of a ship may be as much as 20 feet, and the tidal variation within many harbors is 10 feet or more; provisions may be required to accommodate a change of as much as 30 feet in the elevation of stern and side doors. If the gradient on a ramp is limited to 30 percent to assure rapid discharge and loading of vehicles, a total ramp length of 60 to 70 feet may be required, depending on the elevation at the shore end.

6-6. Transportation facilities.

a. Railroad facilities. Access to two or more trunk lines is desirable. The capabilities of the serving railroads to handle the traffic should be investigated, and backhaul between the shipping points and the port can be avoided.

(1) *Receiving tracks*. The length of each receiving or interchange track should, if practicable, be equal to the length of the maximum single delivery of the serving railroad. The standing-room capacity of the receiving yard should be equal to the average daily volume of cars received in peacetime operation. The design should take into consideration the average or peak movements of cargo, the berthing capacity of the wharf facility, the types of military cargo, and the ship turnabout cycle.

(2) *Classification tracks*. The standing-room capacity of the classification yard should be equal to the

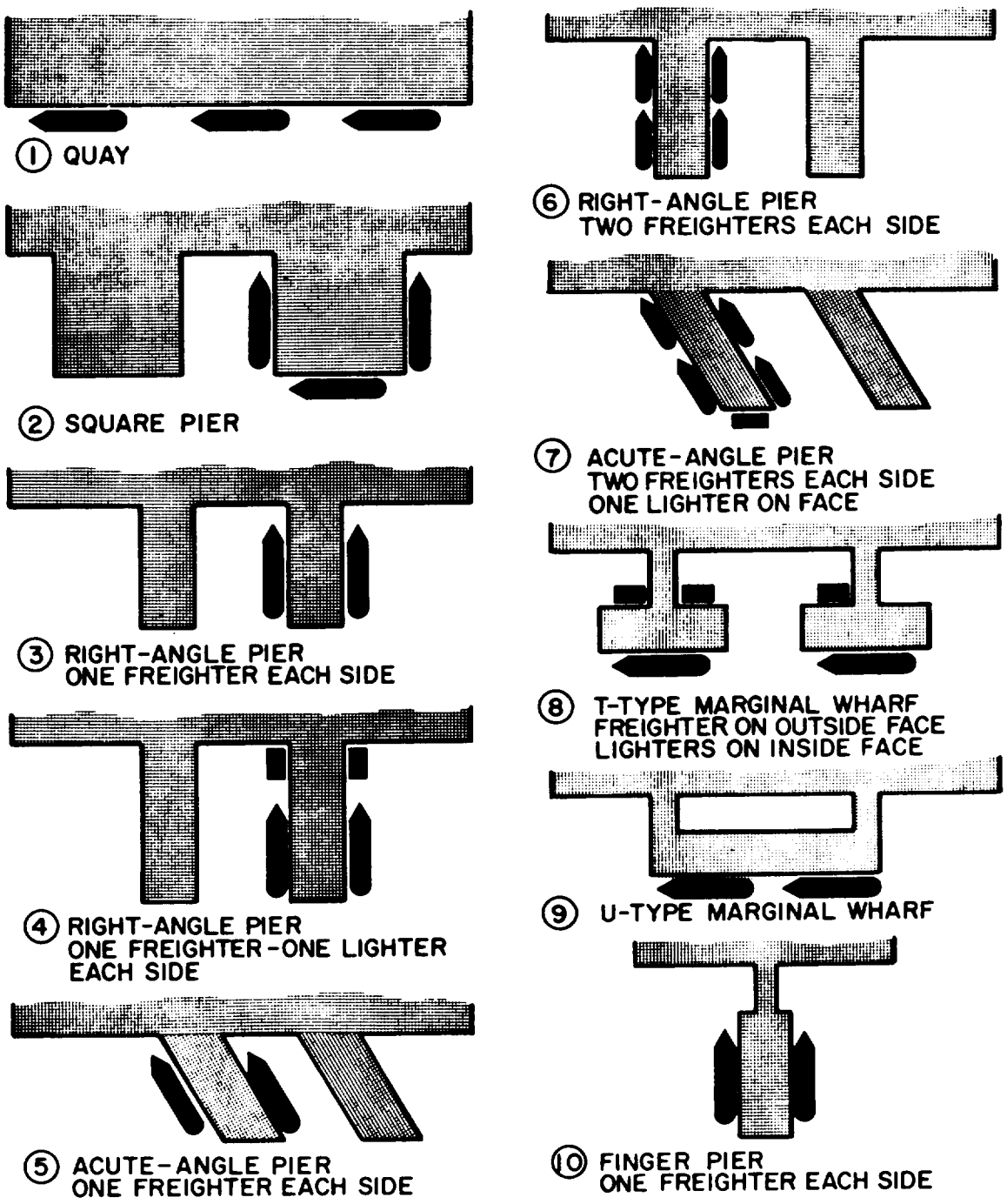
peak daily inbound movement when the port is operating at estimated maximum capacity. The number of tracks can be determined by the number of classifications, and their length by the cars in each classification.

(3) *Dispatching tracks*. The number and length of dispatching tracks can be determined by the same factors used in calculating the size and number of the receiving and classification tracks.

b. Highway facilities. The port should have access to two or more principal highway systems. The residential areas of the labor supply should be considered in designing the access or connecting highways.

(1) *Highway transport loop*. The loop system should provide highways to the wharves, transit sheds, and warehouses. Grade crossing should have maximum visibility, and the gradients of highway approaches may not exceed 3 percent. Space can be provided for grouping trucks and semitrailers by destination and commodity. A truck storage apron can be provided for the trucks required to handle the maximum daily cargo at the port.

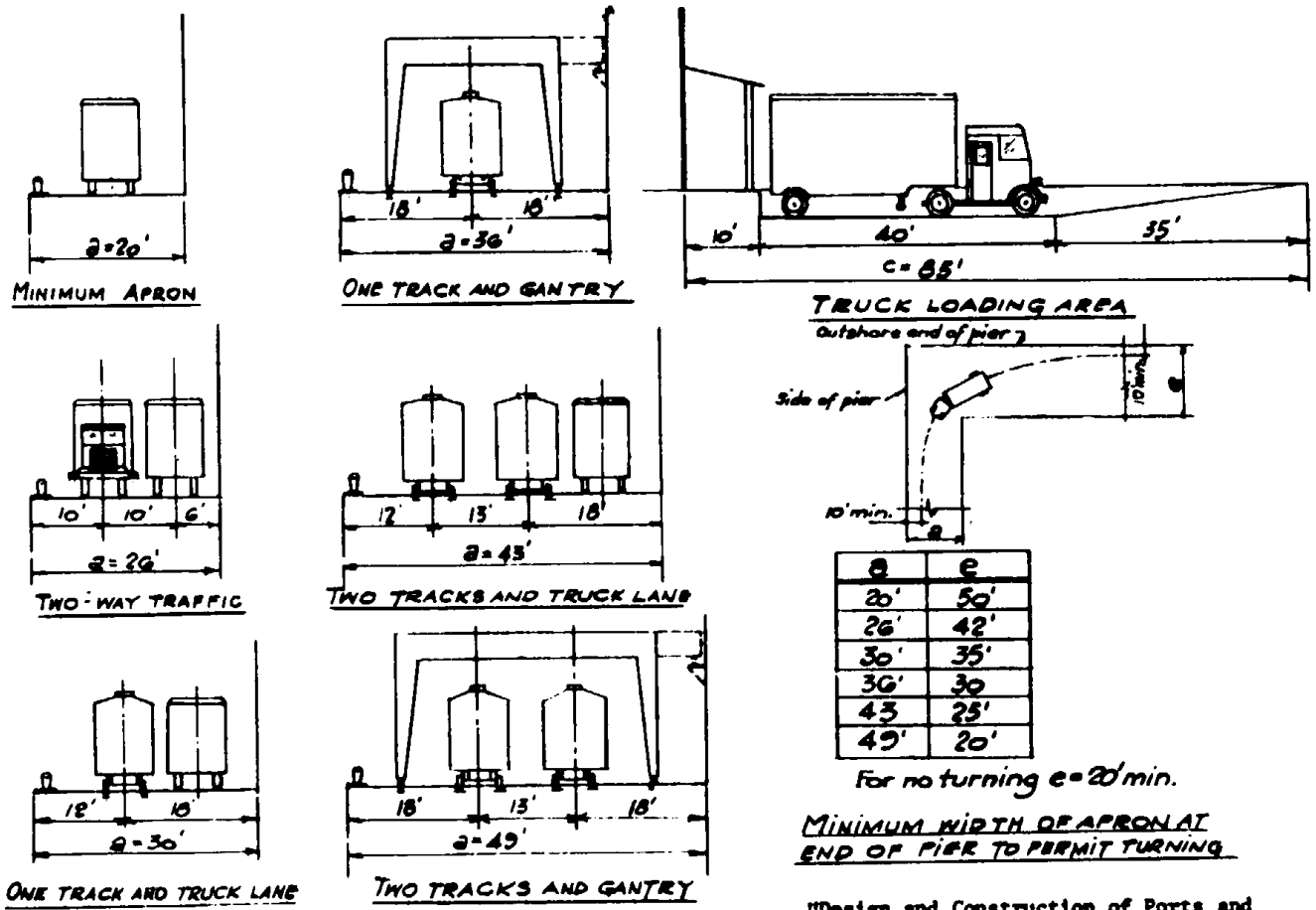
(2) *Pavement design*. Roads, streets, and parking areas can be designed in accordance with the criteria in TM 5-822-5 and TM 5-822-6 (app A.)



NOTE:
NOT TO SCALE. FOR EXPLANATION OF LAYOUT TERMINOLOGY ONLY.

Department of the Army

Figure 6-1. Types of pier and wharf layouts.



"Design and Construction of Ports and Marine Structures" by A. Quinn. Second Edition, 1972 McGraw-Hill Book Company. Used with permission of McGraw Hill Book Company.

Figure 6-2. Various widths of apron for different operating conditions.